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Transportation Research Procedia 6 (2015) 411 – 423

Transportation Research Procedia

www.elsevier.com/locate/procedia

4th International Symposium of Transport Simulation-ISTS'14, 1-4 June 2014, Corsica, France

A revealed/stated preference approach to bus service configuration

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Abstract

This paper proposes a methodology to design an optimal public transport service configuration and forecast demand. It uses a combined revealed preference (RP) and stated preference (SP) approach as well as a Juster scale to ensure strong external validity to both bus choice elasticities and demand forecast. The paper details how elasticities of choice probabilities to bus service characteristics as well as personal and situational factors are adjusted using an RP model based on travellers' reported last trip to work/study or a nearby shopping centre. The Juster scale anchors the model to ensure it provides realistic forecasts through simulation.

Selection and/or peer-review under responsibility of the Organizing Committee of ISTS'14

Keywords: public transport, bus service configuration, demand forecast, revealed preference, stated preference, behaviour change, status quo bias, prospect theory

1. Introduction

The state government of Victoria recognises the central role public transport and infrastructure play in ensuring Melbourne's ongoing liveability, sustainability and competitiveness.

Buses are a vital component of public transport in Melbourne's areas of growth and those not serviced by trains or trams. Ipsos Australia conducted some qualitative research for Public Transport Victoria (PTV) to identify the perceptions of the Melbourne bus network among current and potential bus users.

This research was developed on the basis of the findings of the qualitative research to:

- identify which aspects of bus services are associated with using or not using bus services
- better understand what types of bus services would help change the behaviour of bus potential users, what trade-offs in bus service configuration bus potential users were willing to make.

Selection and/or peer-review under responsibility of the Organizing Committee of ISTS'14
doi:10.1016/j.trpro.2015.03.031

The results of this research are used by PTV to inform strategy, business cases and resource allocation as well as identify ‘quick wins’ where service characteristics can be tweaked to better address the needs of the public.

2. Design

An online survey was designed to investigate how specific bus characteristics (identified in the qualitative research) impact bus use decisions and which modalities of those bus characteristics would maximise the use of bus services among potential users. The bus service characteristics are: frequency, walking time/distance to bus stop, journey time, operating hours, access to real time information.

Participants (bus users and non-users) were asked about their last trip to go to work/study or last trip to the nearest shopping centre (transport mode chosen, availability of bus service, characteristics of bus service, personal and situational descriptors). Two types of trips were selected on the assumption that the evaluation of bus service characteristics is highly situational. People are in a different frame of mind for a work/study trip and a shopping centre trip; shopping centre trips are more episodic whereas trips to work/study are often daily trips of the M-F week. Work/study and shopping centre trips cover a large proportion of the trips of interest to PTV.

Participants were then asked to indicate their preference for a bus service configuration for the same trip in the future. Configurations are based on scenarios varying bus frequency, walking time, journey time, etc. Importantly, potential users had the option to not choose a bus service configuration presented to them and opt-out in favour of their current transport mode (e.g. car, train, etc.). This section of the survey is a choice experiment, and the scenarios are constructed from a fractional factorial design.

Last participants were asked to indicate how likely they were to actually use the bus service for the same trip in the future for three bus service configurations (allocated at random). Likelihood to use the bus service was measured using a verbal probability Juster scale (Juster, 1969). The scale was modified by removing some of the probability points to make it easier to use for respondents without significant loss of information.

No chance, almost no chance [1 in 100]
Very slight possibility [1 chance in 10]
Some possibility [3 chances in 10]
Fairly good possibility [5 chances in 10]
Probable [7 chances in 10]
Almost sure [9 chances in 10]
Certain, practically certain [99 chances in 100]

2.1. Modelling framework

Two models are developed using the data collected:

- A revealed preference (RP) model analysing how the probability of bus use vary as a function of (stated) values of bus characteristics on participants’ last trip. The modalities measured for a participant’s used or available bus service characteristics are stated; we rely on people’s perception of walking time, waiting time at bus stop, journey time, reliability of service, etc. This model provides a reality check of the elasticity of bus use probabilities to the current modalities of bus characteristics. The model is consistent with revealed preference axioms in which a rational choice decision is a choice that can be derived from a person’s preferences (Samuelson 1947, Richter 1966).

- A stated preference (SP) model evaluates how the probability of bus use varies as a function of constructed scenarios of bus characteristics for a future trip of the same type (work/study or shopping centre). The scenarios presented in the choice experiment enable PTV to evaluate participants’ response to modalities of bus service characteristics outside the range captured by the analysis of participants’ last trip (RP model) and test new bus characteristics.

The RP/SP model approach was selected because of the ability of RP models to increase the usefulness of SP models (McFadden 2000, Louviere et al 2000, Mark and Swait 2004). Specifically, elasticities estimated from SP models often derived from choice experiments can be compared for consistency with 'real life' elasticities estimated from RP models, at least within the modalities (of the choice alternatives) common to both the RP and SP setting. In this research elasticities from the RP and SP models are compared for bus service characteristics as well as personal and situational descriptors (e.g. age, access to a car) to ensure that changes in bus use probabilities from changes in bus service characteristics have strong external validity (RP models provide 'real life' elasticities).

2.2. External validity of model

One additional problem often faced by academics and practitioners forecasting behaviour from choice experiments is the need to ensure that such models provide realistic forecasts. Respondents often tend to make more active choices in experiments than they would in reality. Hence SP models from choice experiments can easily overestimate choice probabilities whereas real life choices are impacted by status quo bias (Kahneman et al, 1991) which inhibits change. In order to ensure that forecasts using the SP model for potential bus service configurations are anchored at realistic levels, the characteristics of participants last trip (work/study or shopping centre) were used as input in the SP model developed from the scenarios of bus service configurations; the resulting probabilities of bus use among current and potential users given their last trip characteristics were compared with the reported use of bus for all participants' last trip.

In other words, if the RP model is to provide realistic demand forecasts (choice probabilities) for a range of new bus service configurations (and be useful for strategic planning, resource allocation and decision making regarding the bus network), we should observe that:

- elasticities for bus service characteristics estimated from the SP model are consistent with those of the RP model (wherever the comparison if feasible).
- the SP model provide probabilities of bus use close to 100% among bus users and near zero for non-users) when the bus service characteristics are those of participants' last trip, if necessary once its parameters have been adjusted with those of the RP model.

Measuring the likelihood of nine bus service configurations using a Juster scale provides a means to constrain the choice probabilities to realistic values by offering a nine-point bridge from SP model probabilities to Juster-derived likelihood.

2.3. Sample and recruitment

1,224 respondents took part in the research. Given the two trips of interest (work/study and shopping centre), about 300 respondents were recruited for each group of interest:

- Bus users for work/study trips – those who had travelled by bus for their last trip to work/study;
- Bus users for shopping centre trips – those who had travelled by bus to their nearest major shopping centre;
- Potential bus users for work/study trips – those who had not used the bus for their last trip to work/study but would consider the bus for future trips; and
- Potential bus users for shopping centre – those who had not used the bus for their last trip to their nearest shopping centre but would consider the bus for future trips.

Qualifying criteria were used to recruit only bus users and potential bus users:

- All respondents had to be current Melbourne residents
- Their last or potential bus journey (door to door) would be more than 10 minutes in duration.
- Non-users who reported a low probability of considering a bus for future trips (less than 3 in 10 chance) did not qualify as potential users.

Respondents were predominantly recruited from an online panel where individuals have opted to receive email invitations to participate in online surveys. To supplement the online panel surveys face-to-face interviews at 11 key bus hubs was used to invite bus-users to take part in the survey.

Participants completed the survey online for either a work/study trip or a shopping centre trip (even those who qualified for both trips) so as to ensure a manageable survey length. The average length of the online survey was 20 minutes. The online survey was scripted and administered by Ipsos between 26 Sept and 11 Nov 2013.

Given the survey used quotas of bus users and potential users, the incidence of specific groups of respondents was carefully measured so as ensure correct projection of bus service demand taking into account the actual number of potential bus users in Melbourne. The incidence of those using the bus (no other mode of transport as part of a trip) for work/study measured from the sample is consistent with that provided by the Australian Bureau of Statistics 2011 census.

2.4. Revealed preference model

The bus service characteristics and their modalities were primarily selected for the construction of scenarios for the choice experiment (the SP model). Nevertheless, participants were asked about various aspects of their last trip (to work/study or nearest shopping centre) including the same bus characteristics as those used for the choice experiment.

Below is the list of all trip aspects which were asked of all participants about their last trip, and used to identify which impact decisions to use or not use the bus (RP model).

TRIP CHARACTERISTICS

- Journey length
- Mode of travel
- Purpose
  (Shopping centre trip)
- Day travelled
- Time started journey
- Time of return trip
- No. of people travelling on journey

BUS SERVICE CHARACTERISTICS

- Bus for first or all of trip
- Walk to bus stop in min
- When arrived at stop
- Wait for bus to arrive
- Perceived frequency
- Perceived reliability
- Windy/direct route
- Bus shelter at start
- Use closest bus stop

- Smartphone access
- Smartphone to get bus info

Figure 1 List of trip and service characteristics measured for the RP model

Of these, walking time to bus stop, frequency, reliability and smartphone access to bus info also overlap with the bus characteristics used in the choice experiment (SP model). This provides a means to compare elasticities between RP and SP models.

The RP model was implemented across the entire sample of bus users and non-users' last trip using a binary logit where the choice variable is 1 did use bus on last trip and 0 is did not use bus. Apart from the stated bus characteristics described in figure 1, personal and situational descriptors used as input to determine what impacts bus use include age, gender, access to concession card, access to a car, number of people on journey, work standard M-F 9 to 5 PM week, start time range and return time range. The parameters of the model were estimated using SPSS binary logit through maximum log-likelihood.

All parameters relating to the modalities of bus service characteristics had p values < 0.10 (except for three parameters with p values $> .15$).

2.5. Stated preference model

The following bus characteristics and modalities were selected for the choice experiment. The modalities were the same for work/study and shopping centre trips except for bus frequency which varied from 20 mins to 120 mins.

Walking time at start of journey	Bus frequency	Up to the minute 'real time' information	Chance of bus being late at the time you travel	Difference in your whole journey time	Last bus of the day
5 minute walk	Bus every 10 minutes	Access to 'real time' bus info by smart phone app	Bus is late once a month	Your whole journey is shorter by up to 10 minutes	Last bus at 12 midnight
10 minute walk	Bus every 15 minutes	No access to 'real time' bus info by smart phone app	Bus is late once a week	Your whole journey time is the same	Last bus at 10pm
15 minute walk	Bus every 20 minutes			Your whole journey is longer by 10 minutes	Last bus at 9pm
20 minute walk	Bus every 40 minutes			Your whole journey is longer by 20 minutes	Last bus at 7pm

Figure 2 Bus service characteristics and their modalities used in choice experiment

The choice experiment was designed as a series of 16 scenarios, each presenting a pair of bus service configurations. The scenarios were developed from a 16 run main-effect only fractional factorial design available from Neil Sloane's online library of orthogonal arrays. The 16 bus service configurations were paired with 16 other bus service configurations using the method developed by Street et al (2005) to yield optimal or near optimal designs for statistical estimation of parameters in choice models.

The figure below shows an example of one of the 16 bus service paired configurations used in the online survey. This bus service scenario was presented to potential bus users responding to a work/study trip. Apart from the bus service frequency which varies between work/study and shopping centre trip, the 'opt-out' option also varies for current bus-users and potential bus users: potential bus users need to have an option not to choose any bus service configuration presented to them whereas current bus service users need to have an option to choose another transport mode if neither bus service configurations presented in a paired scenario is acceptable to them.

Thinking about your next trip to work, if these bus options were presented to you to use for all or the first part of your trip, which option would you prefer?

Walking time at start of journey	5 minute walk	15 minute walk	
Bus frequency	Bus every 20 minutes	Bus every 10 minutes	
Up to the minute 'real time' information	Access to 'real time' bus information by smart phone app	No access to 'real time' bus information by smart phone app	
Chance of bus being late at the time you travel	Bus is late once a month	Bus is late once a week	
Difference in your whole journey time	Your whole journey is longer by 10 minutes	Your whole journey is shorter by up to 10 minutes	NEITHER OPTION: I would prefer to travel the way I currently travel to work/study
Last bus of the day	Last bus at 10pm	Last bus at 7pm	
	○	○	○

Figure 3 Example of bus service scenario

The SP model was implemented across the entire sample of bus users and potential bus users for a trip (separate models were also estimated for bus users vs potential users) using a conditional logit model. The parameters of the model were estimated using the NLOGIT module of the LIMDEP econometric software through maximum log-likelihood.

All parameters relating to the modalities of the five bus service characteristics had p values < 0.10 (except for 3 of them that had p value 0.2).

3. Results

3.1. Results of the SP model

The parameters describing the impact of the modalities of bus service characteristics on the probability of choosing a bus option in the choice experiment are almost exactly the same for bus users and non-users (potential users).

If two models are the same, the parameters are aligned up to a scale factor transformation (Swait and Louviere, 1993). The scatter plot below of the parameter estimates among bus users vs non-users shows that the preference structure (the parameter estimates of bus characteristics) is indeed the same for both users and non-users. On that basis, one set of parameters (overall sample) was used for all SP models given the near perfect parameter alignment.

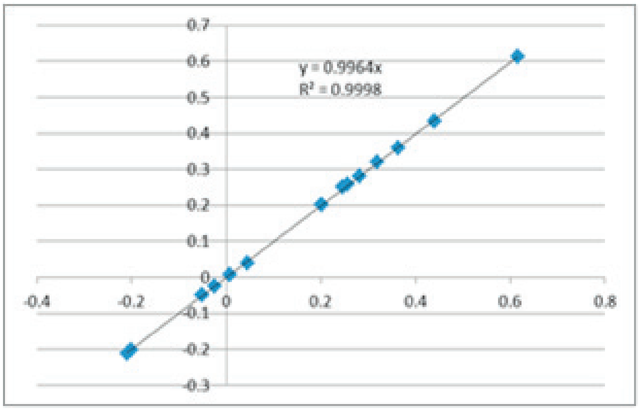

Figure 4 Comparison of the parameters of the SP model (bus users vs non-users)

The ratio of the scale factors (slope of figure 4) is very close to 1 which indicates that the scale factors are indeed the same for both users and non-users. Given that the scale factor is inversely related to the error variance (variance not captured by the preference structure of bus characteristics), the error variance is also the same for both bus users and non-users. Hence, not only do bus users and non-users value bus characteristics in the same way, they also show the same amount of error variance in their choices. We could have expected that bus non-users would be more hesitant in their evaluation of bus service configurations, misunderstand the bus service characteristics presented to them and make more mistakes in their choices but this was not the case at all.

The figure below presents the valuation of bus service characteristics for a work/study bus trip. There is a great difference in how the various bus characteristics are valued: bus frequency has a very strong impact on the likelihood to take the bus whereas having access or not to real time bus information on their smartphone has no significant impact. There is no trade-off between the two: reducing bus frequency whilst providing real time information about when a bus service will arrive at a given bus stop does not maintain the appeal of a bus service configuration. Bus frequency remains the preferred mode of reducing uncertainty of bus availability for both bus-users and potential users.

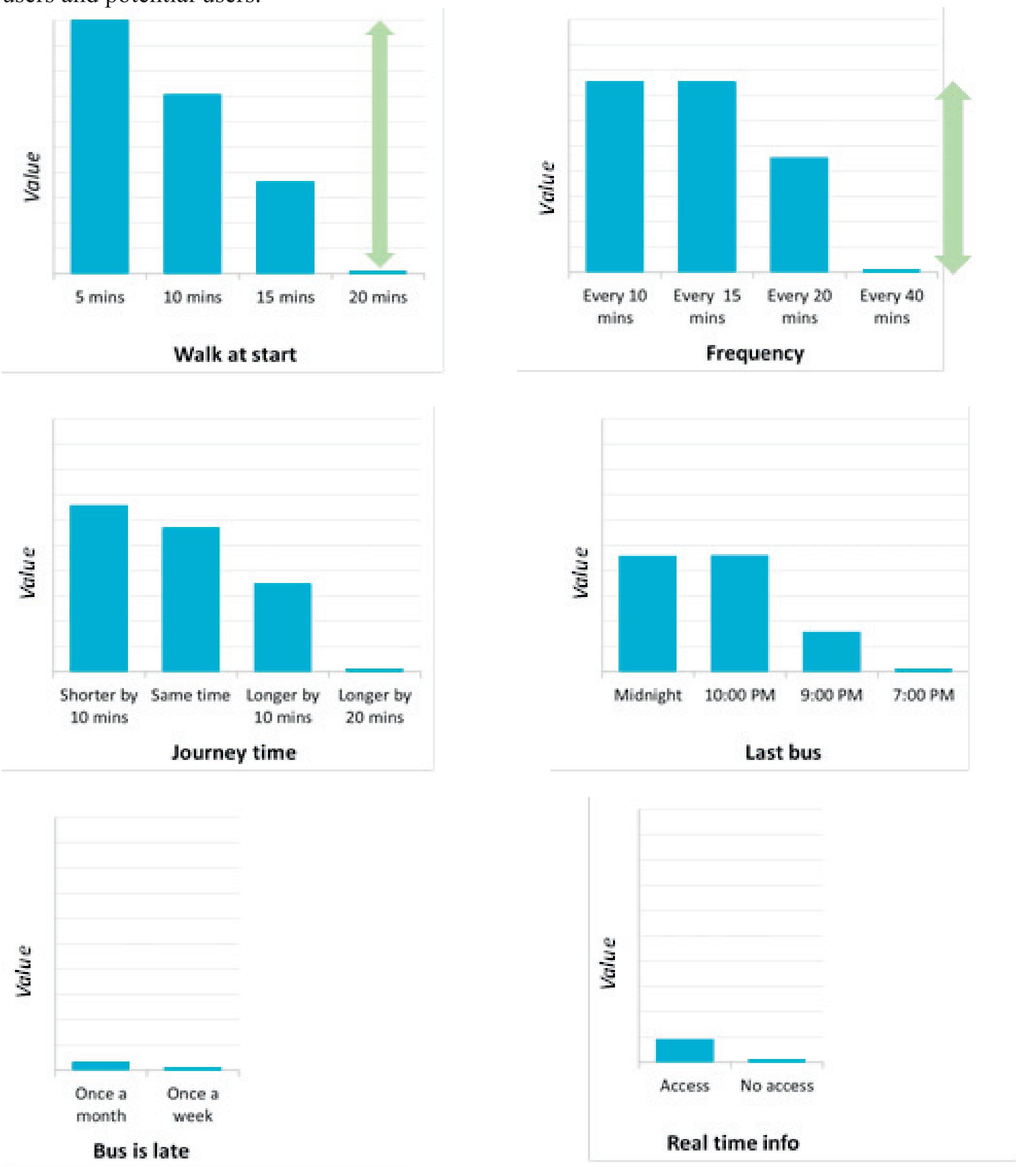

Figure 5: Value of bus characteristics for work/study bus trip

- Every additional 5 minutes of walking time significantly decreases the likelihood to choose the bus.
- 10 minute bus frequency does not increase likelihood vs 15 minute frequency. However, 20 minute (or lower) frequency severely impacts the likelihood to choose the bus.
- Bus configurations which result in journey time to work/study longer by 10 minutes penalise the likelihood to take the bus twice as much as the gain of bus configurations with a journey time shorter by 10 minutes.
- On average, people are indifferent to the last bus being at midnight or 10 PM but the likelihood to choose the bus drops significantly when the last bus is at 9 PM (or earlier).

- Access or no access to real time bus info on smartphone makes very little difference to people's likelihood to choose the bus. So does the likelihood that the bus would be more than 5 mins late once a month or once a week.

The results for the shopping trip highlight key differences with the work trip. This confirms the initial hypothesis that people integrate bus characteristics differently for different types of trips. The valuation of bus characteristics (especially those involving time) is highly situational.

The figure below shows how people value time to walk at start for work/study (a) and shopping trip (b).

a b

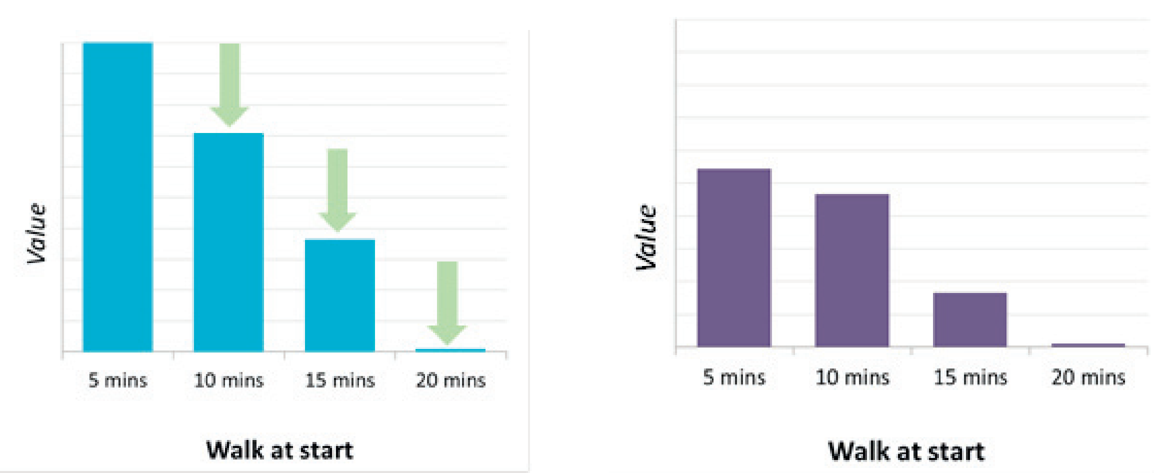

Figure 6 Value of walk at start for work/study trip (left) vs shopping centre trip (right)

People are more sensitive about walking time to the bus stop when they go to work/study than when they go to the nearest shopping centre. In shopping centre trips, they are indifferent to walking 5 or 10 mins. Every minute (or 5 minutes) seems to count when one is on the way to work/study whilst walking time is more 'affordable' when going to the nearest shopping centre.

The figure below shows how people value added or subtracted time (10 minutes) to their journey given a bus service for a work/study trip (left) and shopping trip (right).

a b

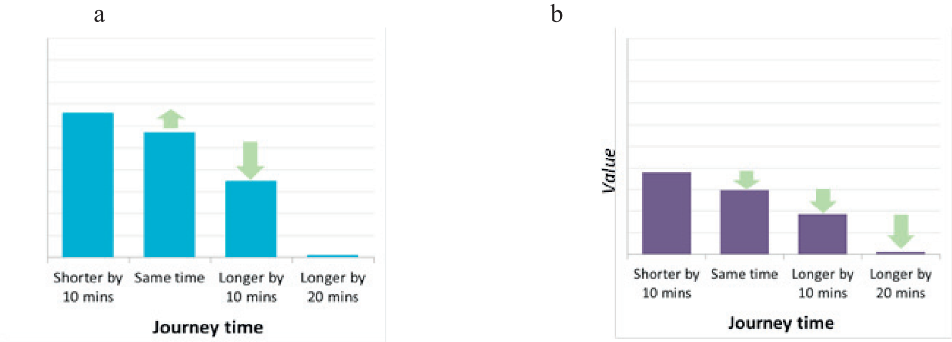

Figure 7 Value of journey time for work/study trip (a) vs shopping centre trip (b)

In both cases, gains (shorter journey times) are valued less than losses (additional journey time). In the case of the work/study trip, 10 minutes longer journey time is valued twice as much as 10 minutes shorter journey time. This asymmetry in the bus service utility function is exactly in line with what Kahneman and Tversky (1979) found in their "prospect" theory: on average (across a range of situations and participants), losses are valued twice as much as gains.

3.2. Results of the RP model

Walking time to bus stop, reliability of bus service, direct routing and presence of a bus shelter (for work/study) are the only bus service attributes found to impact participants' last trip in the RP model.

Besides, for work/study trip RP model, the following personal and situational descriptors have a strong impact on the likelihood to use the bus: degree of access to a car, age, working a standard M-F 9-5 week and starting their return trip between 3 PM and 7 PM. For the shopping centre trip RP model, the significant personal and situational descriptors are: age, gender, degree of access to a car, a single-person trip and starting the forward journey between 9.30 AM and 3 PM.

Both RP models (work/study and shopping centre) have an 80% probability to correctly classify a participant as a bus user or non-user based on the few bus service characteristics and personal and situational descriptors listed above.

3.3. Comparison of SP and RP model elasticities

Probabilities to choose bus were calculated for all bus service characteristics, personal descriptors and situational descriptors found to significantly impact bus use in both RP and SP models.

The table below shows how bus choice probabilities decrease when walking time increases (from 1-10 minutes to 11+ minutes) and perceived bus reliability decreases from late once a month to late once a week for a work/study trip and a shopping centre trip. The changes in choice probability for bus are presented for the RP model (last trip analysis) vs the SP model (choice scenarios).

Table 1 Elasticities of RP and SP model (as changes in bus choice probabilities for changes in walking time and expected bus reliability)

WORK/STUDY	Last trip (users + non-users)	Choice scenarios (users + non-users)
age (from 30 years old to 60 years old)	30%	41%
work standard week (from M-F 9-5 to other)	1%	10%
access to a car (from never to always)	73%	6%

SHOPPING CENTRE	Last trip (users + non-users)	Choice scenarios (users + non-users)
age (from 30 years old to 60 years old)	28%	30%
gender (from female to male)	12%	1%
number of people on trip (from 1 to more than 1)	19%	5%
access to a car (from never to always)	39%	4%

The impact of age on bus choice probabilities is very much the same for both models. The impact of the work standard week, gender and the number of people on the trip do vary between the two models but the impact remain small to moderate for both models.

On the other side, the dampening impact of always (vs never) having access to a car on bus choice probabilities is very different between the two models, especially the work/study trip. The RP model (analysis of the last trip) reveals a very strong negative impact of people being able to access a car on their chance to take the bus to go to work/study or a shopping centre. Impact of access to a car on bus choice probabilities is marginal for the SP model.

In the experiment, participants seem to behave as if they were only paying attention to the bus service characteristics presented to them in the scenarios, and ignoring crucial aspects of their personal circumstances that do impact their choice of transport mode, something akin to over-focus.

4. Adjustment and model validation

4.1. Adjustment

The similarity in the elasticities of common bus characteristics found to impact choice both in the RP and SP setting provides a degree of confidence that participants are using and evaluating the bus characteristics in the SP model in a manner consistent with what the analysis of their last trip reveals (RP model).

The parameters of the SP model for bus service characteristics were not adjusted but parameters related to personal characteristics and circumstances, especially access to a car were adjusted as the SP model underestimates their true impact on bus choice.

The adjustment was conducted by increasing the size of the parameters for:

- access to a car and working week for the work/study trip model,
- access to a car, gender and number of persons on trip for the shopping centre trip model.

These parameters were increased for the SP model so that the ratios of each adjusted parameters to parameters of the bus service characteristics were similar for both the RP and SP model. The use of the ratio rule for the adjustment neutralises the effect of the scale factor inherent to the parameters of RP and SP models.

4.2. Model validation

To validate the SP model, the characteristics of the participants' last trip were used as input in the SP model. The SP model should yield a bus take-up close to zero among non-users.

In addition to adjusting the parameters for the personal and situational descriptors of the SP model, the choice probabilities are converted using the results of the Juster scale question for the nine bus configurations. The response to the Juster scale for a given bus service configuration is calculated by means of a weighted average of the top three points: 99 out of 100, 90 out of 100, 70 out of 100 with weights respectively .99, 9 and .7. All other weights are set to zero.

The nine points provide a sufficient bridge to convert the SP model-adjusted probabilities into final bus choice probabilities. The figure below shows the conversion of SP model probabilities into final shopping trip and work/study probabilities.

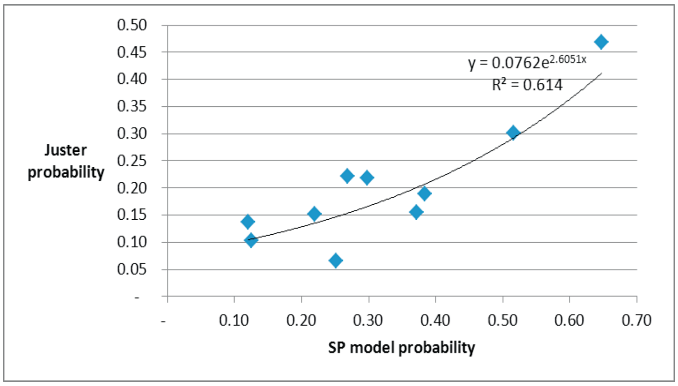

Figure 8 Shopping trip – conversion of probabilities from SP model to Juster (total sample)

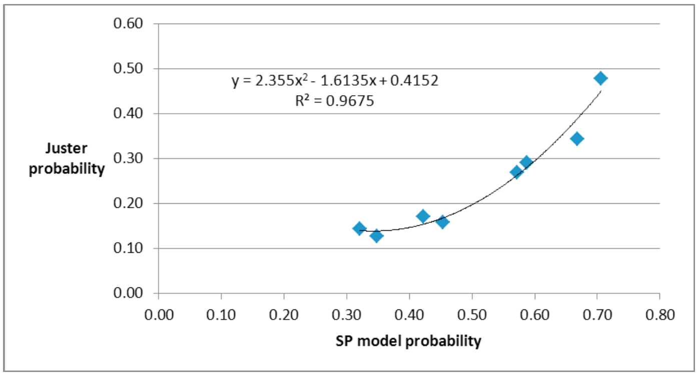

Figure 9 Work/study trip – conversion of probabilities from SP model to Juster (total sample)

The line fit is reasonable for the shopping trip (61%) and excellent for the work/study trip (97%); hence the conversion to Juster-derived bus choice likelihood from SP model probabilities is possible.

The table below shows the forecast (mean choice probability for bus) among non-users for both types of trip:

- without parameter adjustment
- with parameter adjustment from RP model
- with parameter adjustment from RP model and conversion into Juster-derived bus choice probabilities.

Table 2 SP model forecast of proportion of participants using bus on their last trip and comparison with stated bus use

	work/study trip	**shopping centre trip**
Total sample model		
without adjustment	83%	87%
with adjustment of SP parameters	71%	64%
with adjustment of SP parameters **and** Juster conversion	45%	42%
Stated sample proportion of bus use on last trip	49%	50%
Non-user model only		
without adjustment	49%	75%
with adjustment of SP parameters	29%	29%
with adjustment of SP parameters **and** Juster conversion	6%	2%
Stated sample proportion of bus use on last trip	0%	0%

5. Discussion

The RP model did identify walking time and lateness as bus service characteristics that impact bus choice. However, bus frequency was not found to significantly affect bus choice in the last trip's analysis (RP model for work/study and shopping trip). Given frequency was found to be highly influential on choices in the choice experiment (SP model), the question arises as to why the RP model did not return a significant parameter for frequency.

The answer possibly lies in the fact that the RP model relies on bus service characteristics which are stated by participants (users of bus on last trip as well as non-users who are able to provide details on the bus service available to them although they did choose a different transport mode). If participants, especially non-users have incorrect memories of bus service frequency, the effect of this could be to increase the standard error of the parameters and affect statistical significance.

The adjustment of SP parameters using the RP model provides some correction of bus use probabilities for both the work/study and shopping trips. The resulting probabilities however, when the model is run with the participants last trip bus characteristics as input are still well away from the 50% expected at total sample level and zero among bus non-users. Only the Juster-converted probabilities enable the SP model to yield probabilities that are in line with actual bus choice for participants' last trip; especially the total sample model for work/study (45% vs actual 49%) and the non-user shopping trip model (2% vs actual 0%).

Awareness is a critical step in building motivation for behaviour change. The experiment makes all participants aware of the characteristics of bus services presented to them. In reality, not all potential users would become aware of all characteristics and bus demand among non-aware potential users is conditional to changes in knowledge of bus service characteristics (no change in knowledge of bus service characteristics means no change in behaviour). Given that the parameters for the frequency attribute in the RP model are not significant, it is possible that current non-users have insufficient knowledge of actual bus frequency on services available to them to travel to work/study or the nearest shopping centre. Building awareness of bus service characteristics (in particular bus service frequency) is an essential step to generate demand among current non-users.

Awareness is only one step in the behaviour change process. Michie et al (2011) propose Capability-Opportunity-Motivation-Behaviour (COM-B) as a framework to identify barriers and leverage points to change behaviour, and create effective interventions. There are serious hurdles for current non-users of bus services to actually change behaviour, regardless of the impact of changed bus service characteristics on their motivation. The challenge for public transport organisations is to ensure that the impact of these hurdles is minimised and leverage points are found to facilitate the change in behaviour. In the case of bus services, the biggest hurdles are found at the very start of the bus journey:

- Walking to the bus stop is both a physical and psychological **capability** issue for behaviour change:
  - physical because 11% of potential bus non-users say they cannot easily walk more than 500 metres
  - psychological because a much larger percentage (35%) do not walk ten minutes or more continuously at least once a week (Ipsos, 2013).
- Easy access to a car parked on the street or in the garage creates an environment that limits the **opportunity** for potential users to actually use the bus. The car is an alternative mode of transport to public transport that is immediately visible and available. The absence of 'upfront costs' for the car option further impacts motivation for the bus option where the upfront cost is to first walk to the bus stop (the valuation in the SP and RP models shows that walking more 10 minutes strongly decreases the appeal of the bus service).

Part of the challenge for an intervention going beyond creating awareness of changes to bus service characteristics would be to turn the initial walk to the bus stop into a positive (rather than its current negative valuation for every 5 minutes added to the walk). Reframing the context of the choice of transport mode to one including wellbeing rather than just transport needs may provide a route to achieve more effective behaviour change among current bus non-users.

6. Conclusion

Public transport policy relies on forecasting models that capture behaviour as accurately as possible. Forecasts need to be anchored in reality and elasticities consistent with the way people actually behave.

This research confirms that RP models are an indispensable component of SP models/choice experiments when no other data (e.g. consumer panels, market data, historical databases) are available to test the external validity of elasticities provided by SP models. Moreover, once the scale factor inherent to each type of model is taken into account, parameters of SP models can conveniently be adjusted with those of RP models where warranted.

Once all necessary adjustments have been made, the use of a Juster probability scale provides final insurance to check that probabilities remain anchored at realistic levels and the model can be used for strategic planning and decision making through simulating new bus service configurations.

The elasticity of bus choice probability to variation in journey time shows that the (publicly available) continuum of knowledge about judgment and decision making can provide an additional source of external validity to models of choice behaviour. The asymmetry of longer vs shorter journey time in the case of bus services is exactly in line with the average found by Kahneman and Tversky (op cit) over a range of situations and subjects.

Acknowledgements

The author would like to thank Public Transport Victoria for authorising the publication of this research, and for their help and assistance in the development of the research. The author would also like to acknowledge Dan Evans and Julie Young from the Ipsos Social Research Institute team in Melbourne, Vic.

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